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ENHANCEMENT AND INVESTIGATION OF MECHANICAL PROPERTY OF ELECTROSPUN MAT PREPARED USING CDC

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Abstract. Collector plate setup in electrospinning plays a vital role in the properties of nanofibre mat. This article applies a new design concept and developed a new collector plate assembly known as Constrained Dynamic Collector (CDC). Using this setup (CDC) preparation of mat (Acrylic/DMF) and mechanical properties were evaluated.

Acrylic/DMF nanofibre mats were prepared and their microstructure and mechanical properties were characterized by SEM, INSTRON-tensile tester.

1. Introduction

Electrospinning is a broadly used technology for nanofibre formation which utilizes electrical forces to produce nanofibres with diameters ranging from 2nm to several micrometers. The notable applications of this technique are tissue engineering, biosensors, filtration, wound dressings, drug delivery and enzyme immobilization, etc. (Nandhana Bhardvaj et al., 2010). A schematic diagram of electrospinning applications in various fields is shown in Figure 1.

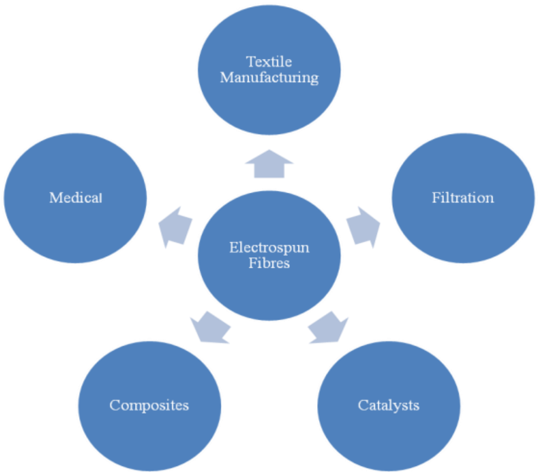


Figure 1.Applications of Electrospun fibres in different sectors

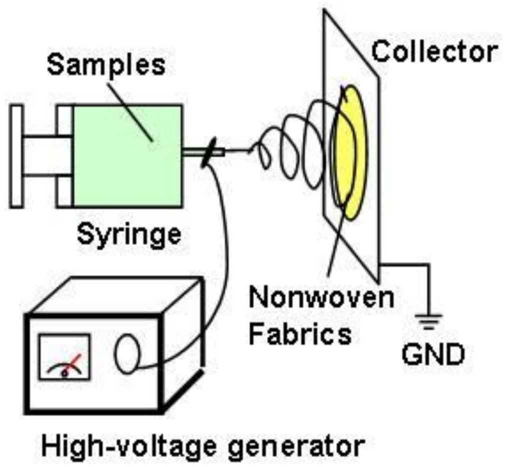


Figure 2.Electrospinning Apparatus Setup

An electrospinning system consists of three major components: a high voltage power supply, a spinneret and a grounded collecting plate. The typical setup of electrospinning apparatus is shown in figure 2.

An important aspect of the electrospinning process is the type of collector used. Generally stationary aluminium foil is used as a collector produce aligned fibres for various specific applications, other collectors such as wire mesh(Wang et al.,2005b),pin(Sundaray et al.,2004),parallel or gridded bar(Li et al.,2004),rotating rod, rotating wheel (Xu et al.,2004) are used.

The fibre alignment is determined by the type of the target/collector and its rotation speed (Kumbar et al., 2008). The generated nanofibres are deposited on the collector as a random mass due to the bending instability of the highly charged jet (Renekar et al., 2000, Shin et al., 2001a)

In this work Constrained Dynamic Collector is used to produce mat and investigated the improvement in mechanical property.

2. Materials and Methods

2.1 Solution Preparation

Acrylic/ Dimethylformamide (DMF) were used as a polymeric solution. Acrylic fibres are synthetic fibres made from a polymer (Polyacrylonitrile). Polyacrylonitrile of 12 weight% was dissolved in DMF under constant magnetic stirrer in 12-14hrs for the preparation of solution for electrospinning.

2.2. Electrospinning Setup

The stationary collector plate was replaced by our newly designed collector plate termed as CDC. The details of the design are not revealed for patent make. Electrospinning was carried for two hours to fabricate mat. For comparison purpose mat was also fabricated using static collector for same electrospinning parameters.

2.3. Scanning Electron Microscopy (SEM)

The surface morphology of the fibre mat produced by conventional static collector assembly and CDC setup was studied using SEM (TESCAN VEGA3 SBU, USA). The fibre samples collected on the aluminium foil was peeled out and then mounted in the SEMs sample holder using conductive black carbon tape and sputter coated. This sample holder was loaded with fibers of CDC and static collectors then the sample coated with gold to ensure the enough conductivity of the sample while performing SEM. Now these gold coated samples were visualized under SEM at various magnifications.

2.4. Tensile testing:

Specimens of 20mm×10mm (length×width) under ASTM standaredD882 were cut from both static and CDC electrospun mat in different angles(0,30,60,90,120,150,180,….,360) as shown detail in Fig.3. The specimens are tested on an UTM INSTRON 3369. The cross head rate for the tensile test is 5mm/min. Thickness of the specimen for both static and CDC was 0.08mm.

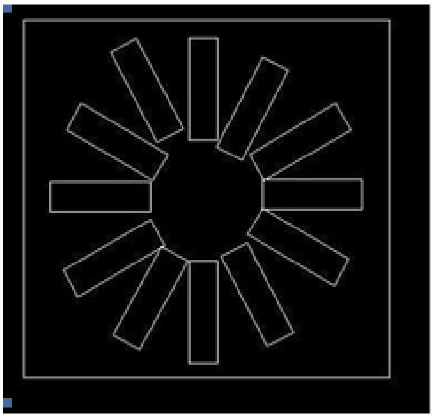


Figure 3. Specimen Preparation

		No. of fibres	
Sl.No.	Fibre Length/No. of cross links	STATIC	DYNAMIC
1	Above 500mm	1	2
2	400-500	Nil	3
3	300-399	2	12
4	200-299	8	16
5	Below 200mm	46	40
6	No. of cross links	147	183

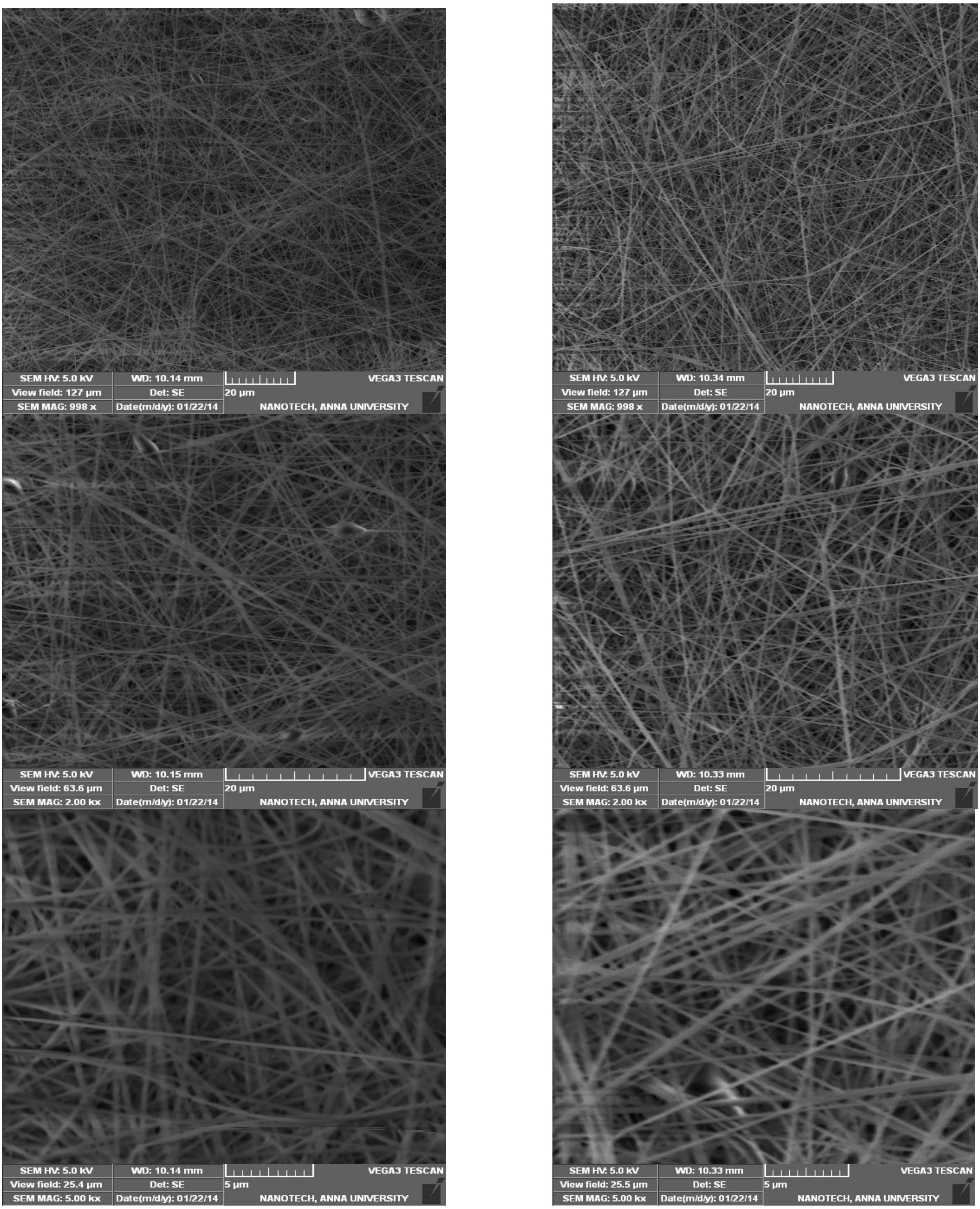
Table 1.

3. Results and Discussion

3.1. Morphological characterization

The SEM morphology of the electrospun mat shows nano dimension of fibres[Fig.4] . Figure 4 shows the images of nanfibres collected by both static and CDC collector.

STATIC **DYNAMIC**



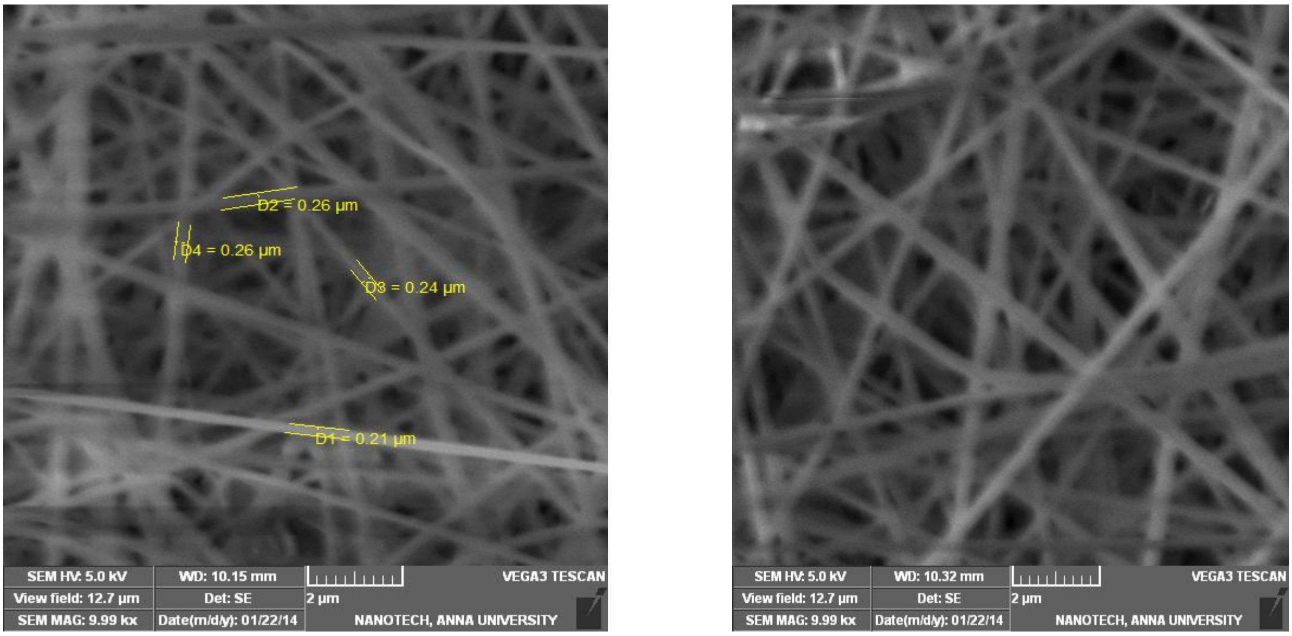
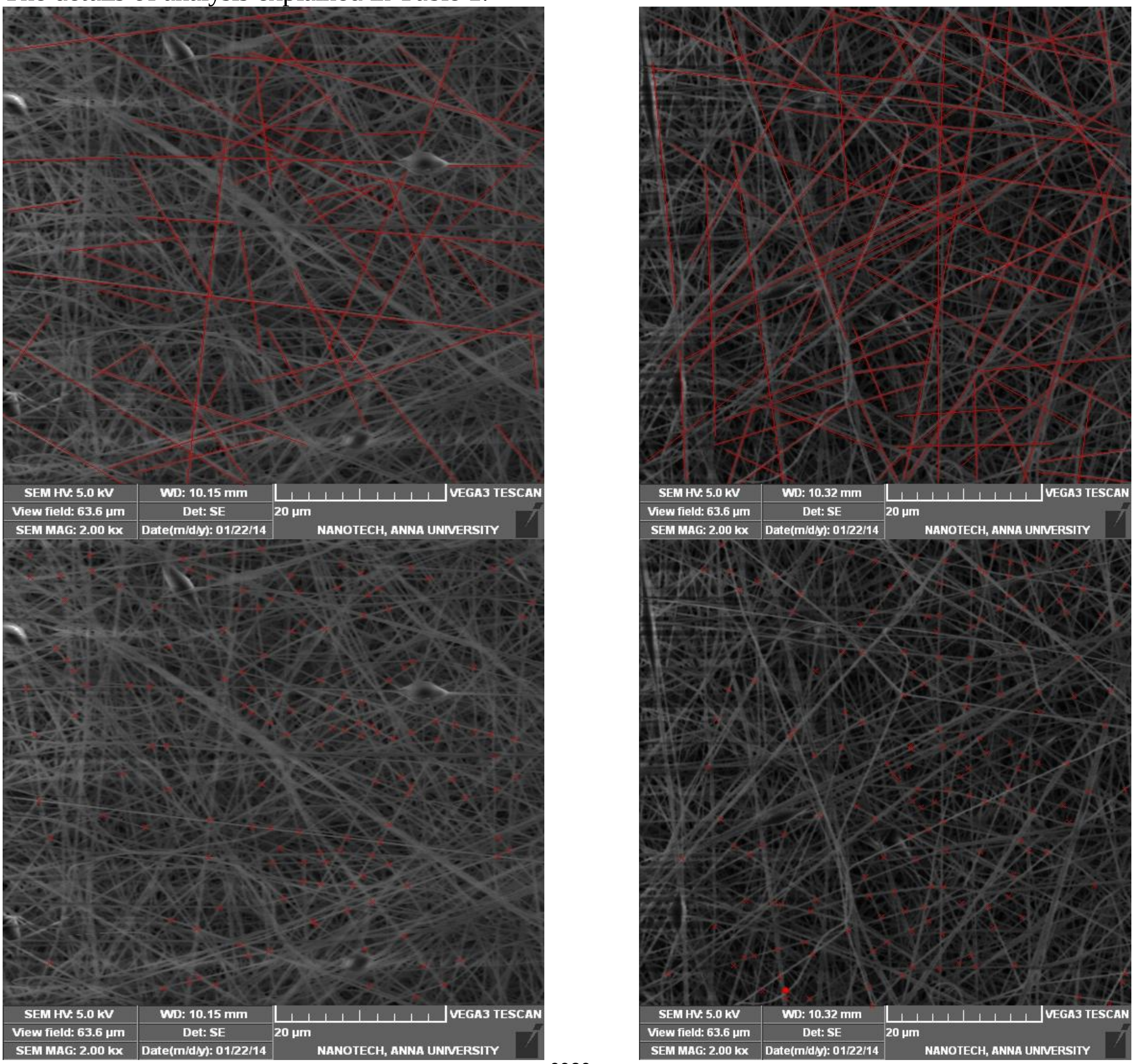


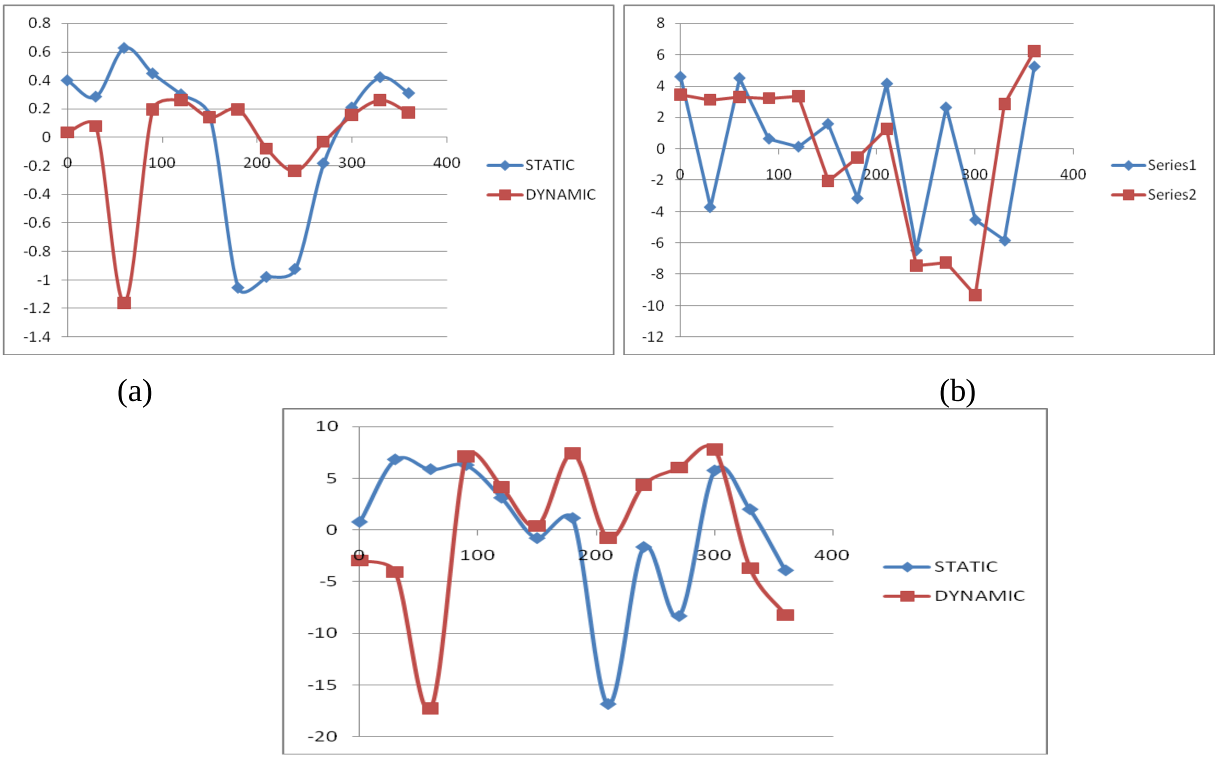
Figure 4. SEM image of fiber deposited on (i) Static (ii) CDC

These two SEM images (SE MAG 2 kx) were analyzed by Digimizer software as shown in Fig. 5. The details of analysis explained in Table 1.



3.2 Mechanical Properties:

Mechanical properties were analyzed by the results from INSTRON 3369. X axis represents Fibre mat sample specimen inclination angle and Y axis represents Difference between Mean and value at corresponding angle.



(a) (b)

(c)

Figure 5.Mechanical Property Analysis (a)X-Angle θ Y-Tensile stress(MPa) (b)X-Angle θ Y-Tensile strain(%) (c) X-Angle θ Y-Youngs Modulus (MPa)

Mat prepared using CDC is more even compared to the static collector. The number of lengthy fibres and cross links more in CDC compare to static collector. Hence, the strength of the electrospun mat improved when the nanofibre is prepared through CDC than static collector.

4.Conclusion

The effect of collector plate design on electrospun mat analyzed and improved. Newly designed CDC gives lengthier, cross linked and aligned fibres. These leads to improve the mechanical property of electrospun mat. Final result shows that the CDC gives the best improved mechanical property electrospun nanofibre mat when compared to nanofibre from static collector. The reason would be due to role of collector dynamics leading to more number of cross links. Hence, a further study to establish and correlate the efficiency of CDC is required.

References

[1] Nandana Bhardwaj,Subhas.C.Kundu. Electrospinning: a fascinating fiber fabrication technique.Biotechnology Advances 28(2010)325-347.

[2] Trinh Quang Bao, Rose Ann Franco, Byong Tack lee, Materials properties and characterizations of cross linked electro-spinning raspberry ketone incorporated polyvinyl alcohol/gelatin fibrous scaffolds biomedical science and engineering, 2011, 4,1-9.

[3] Danya M Larin, Robert M Stefani, Linda zhang, Stacia Furtado, Richard A. Hopkins Edith Mathiowitz. Multifunctional polymeric microfibers with prolonged drug delivery and

structural support capabilities. Acta biomaterialia 8(2012) 1891-1900.

[4] Biomaterials –A nano approach. Seeram Ramakrishna, Murugan Ramalingam,T S sampathkumar Winston O. Soboyejo.CRC Press

[5] Rahul Sahay, Velmurugan Thavasi and Seerm Ramakrishna. Design modifications in electrospinning setup for advanced applications. Journal of nanobiomaterials (2011) Article ID 317673

[6] S. Farboodmanesh et al. Investigation of Electrospun Nanofibrous Scaffold mechanical properties. NSTI-Nanotech 2008.

[7] Dr.Tong lin .Nanofibers- Production, Properties and Functional Applications.INTECH,2011